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This grant provided funds for purchase of high-speed signal processing equipment to be used in connection with psychophysical research on human sound localization. The equipment consisted of a general-purpose minicomputer (VAZ-11/750), attached array processor, high-resolution analog input-output, miscellaneous communications and graphics peripherals, and software. The equipment was installed three months into the grant period, and was fully operational three months later. In the remaining six months of the grant period, research was begun on several on the experiments outlined in the original proposal. These experiments addressed the issues of intersubject variability, frequency range necessary for localization, and influence of spectral smoothing.

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FINAL TECHNICAL REPORT

AFOSR- 5-0151

Human Sound Localization
New Research Techniques and Applications

Summary: This grant provided funds for purchase of high-speed signal processing equipment to be used in connection with psychophysical research on human sound localization. The equipment consisted of a general-purpose minicomputer (VAX-11/750), attached array processor, high-resolution analog input-output, miscellaneous communications and graphics peripherals, and software. The equipment was installed three months into the grant period, and was fully operational three months later. In the remaining six months of the grant period, research was begun on several of the experiments outlined in the original proposal. These experiments addressed the issues of intersubject variability, frequency range necessary for localization, and influence of spectral smoothing. Since these experiments required extensive software development, none has been completed. At the end of the grant period, all hardware and software needed in the research was in place, and the research was proceeding along exactly the same lines as outlined in the original proposal.

List of equipment actually purchased:

ITEM	MANUFACTURER	CHARGE TO GRANT	
Central Processing Unit			
VAX 11/750 CPU	DEC	40,000.00	
Memory–3 each	National	2,976.00	
		***	42,976.00
Speed and Arithmetic Enhancements			
EXOS Ethernet Interface	Excelan	2,711.50	
EXOS VAX Ethernet software	Excelan	4,250.00	
VMS link level driver	Excelan	200.00	
Graphics Workstation - Ethernet software	Silicon Graphics	900.00	
EXOS 8043 VAX software	Excelan	4,250.00	
Second unibus, DW750	DEC	6,160.00	
Floating pt unit, FP750	DEC	7,480.00	
Charge, software loading	DEC	600.00	
Cabinet, 2 each	DEC	1,958.00	
VAX cable, 2 each	DEC	106.25	
SPSS-X Statistical Package	SPSS	1,250.00	
		***	25,615.75
Mass Storage			
Storage Module, Disk, tape	Emulex	41,181.00	
Fujitsu disk drive	Fujitsu	9,940.00	
Slide mounting kit	Fujitsu	185.00	

ITEM	MANUFACTURER	CHARGE TO GRANT	
Bezel, 10.5"	DEC	120.00	
Bezel, 5.25"	DEC	30.00	
		***	51,456.00
Communications			
Multiplexer	Emulex	4,200.00	
Spirit 220 terminals, 4	C.Itoh	3,184.00	
		***	7,384.00
Array Processor			
MiniMap Array Processor	CSPI	36,575.00	
MiniMap Memory	CSPI	8,550.00	
Analog I/O Software	Digital Sound	2,700.00	
Additional Vax Memory	National	1,984.00	
		***	49,809.00
Software			
Fortran 77 license	DEC	4,549.60	
Signal Processing package for VAX	Signal Technology	8,900.00	
		***	13,449.60
Graphics			
Laser Printer	Talaris	9,490.00	
Fonts	Talaris	1,700.00	
Plotting Software	Talaris	1,700.00	
MASS11 for VAX	MEC, Inc.	3,250.00	
MASS11 for IBM PC	MEC, Inc.	400.00	
		***	16,540.00
Analog Input/Output			
High Resolution D/A converter	Digital Sound	17,680.00	
		***	17,680.00
Current Lab System Upgrades			
Dual processor upgrade	Masscomp	7,500.00	
Disk controller	Masscomp	5,250.00	
Ethernet board replacement	Masscomp	1,875.00	
		***	14,625.00

ITEM	MANUFACTURER	CHARGE TO GRANT	
Remote Data Acquisition			
Waveform analyzer, Data 6000	Analogic	5,995.00	
14-bit A/D, model 610	Analogic	1,995.00	
Memory, model 686	Analogic	1,550.00	
High speed interface	Analogic	1,995.00	
Cabinet	Analogic	1,800.00	
Rack mounting kit	Analogic	150.00	
		***	13,485.00
Upgrade Computer Terminal			
Cpu board	Silicon Graphics	2,800.00	
Ram--high speed, 1.5mb	Silicon Graphics	2,770.00	
Disk drive	Silicon Graphics	2,875.00	
Cartridge tape option	Silicon Graphics	2,910.00	
Disk/tape controller board	Silicon Graphics	2,895.00	
		***	14,250.00
**********			267,270.35

Research Projects Initiated During Grant Period:

1. Intersubject variability. Previous work on this project revealed large intersubject variability in estimates of the outer ear acoustic transfer functions. Evidence of the functional significance of this variability came from tests in which a subject listened over headphones to sounds which had been synthesized so as to incorporate a different listener's outer ear transfer characteristics. Results from these experiments, in which subjects, in effect, "listened through another person's ears", showed that localization was substantially degraded under these conditions.

In the present grant period the intersubject variability in outer ear transfer functions has been reduced by implementing a greatly improved microphone stabilizing scheme. With the new measuring techniques, the degradation of localization which previously accompanied "listening through another person's ears" appears to have been substantially reduced. Only pilot work on this topic has been completed. If the pilot results are borne out in future research, this result could have important implications with regard to the potential practical application of the stimulus synthesis techniques; it may not be necessary, as previously believed, to synthesize stimuli specifically for each and every listener.

2. Necessary Frequency Range: Previous research from this laboratory has established that a veridical three-dimensional auditory spatial experience can be achieved with headphone-presented sound as long as outer-ear acoustic effects are present. These effects might be expected to be significant only at high frequencies, given the size of the pinna relative to the relevant acoustic wavelengths. One simple research project initiated during the grant period examined this issue directly, by measuring the impact

on localization of low-pass filtering the stimulus. Pilot results suggest, surprisingly, that headphone-presented sounds retain their three-dimensional externalized character even when low-passed as low as 2 kHz. Further objective measurements of localization performance under these conditions has been undertaken.

3. Influence of Spectral Smoothing: The direction-dependent acoustic filtering provided by the outer ears is spectrally complex; the bandwidths of several prominent resonances are narrow, causing sharp spectral peaks and valleys in the outer ear transfer functions. While it is clear that outer-ear filtering is perceptually important, the imperfect spectral resolution of the auditory system would suggest that not all the spectral detail provided by the outer ears is relevant. Research currently in progress will evaluate the influence on localization performance of spectral smoothing, especially that designed to mimic the "smoothing" caused by the limited frequency resolution of the auditory system. Some spectral smoothing techniques would lead to reductions in the complexity of the stimulus synthesis algorithms. These are especially interesting, since if the algorithms can be made simple enough, real-time synthesis of three-dimensional auditory displays would be feasible.